STRUCTURAL DESIGN - II

01. Basic Properties of Structural Steel

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January 23, 2021

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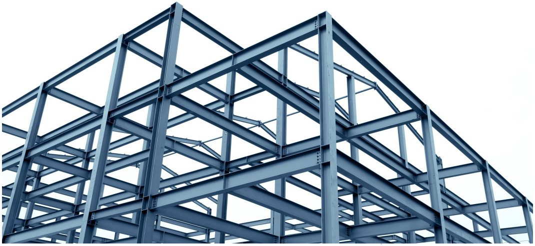
Introduction

Structural Steel - an important building material

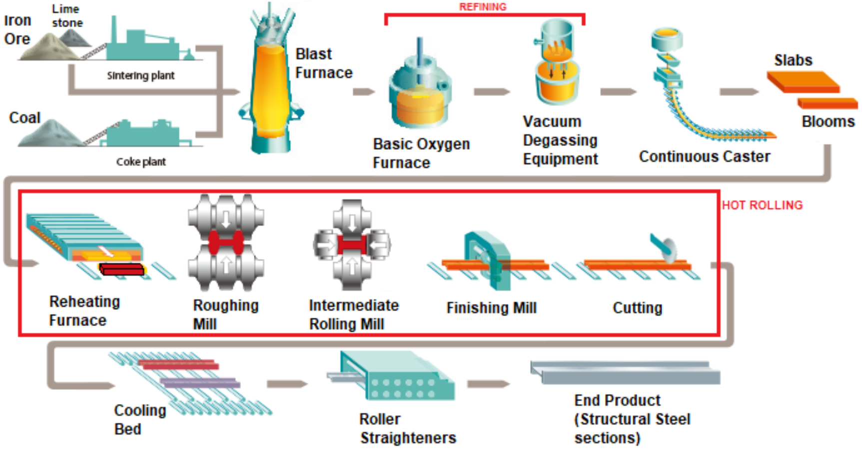
- Basically, **Low Carbon Steel**
  - Primary Constituent: Iron [98-99%]
  - Secondary Constituents:

    Carbon (C) [0.1-0.25%]
    Manganese (Mn)
    Sulphur (S)
    Phosphorus (P)
    Silicon (Si)
- Useful structural material (as load bearing girders, frames and trusses), and hence known as **Structural Steel**.



Introduction

Manufacture of Structural Steel



Introduction

Manufacture of Structural Steel

1. **Melting:**
   Raw materials are charged into blast furnace and heated to 1600^{o}C, produces molten metal.
2. **Refining:**
   Basic-Oxygen furnace & Vacuum-degassing equipment are used to reduce impurities (C, Mn, S, P etc.) in the molten metal.
3. **Casting:**
   The liquid steel thus formed is cooled and then cut/casted into semi-finished products (like slabs, blooms and billets).
4. **Hot Rolling:**
   These semi-finished products are heated at 1200^{o}C to make it malleable and then rolled into structural steel sections of specific cross-sectional shape (I, C, T, L, tubes, bars, flats, plates etc).

Structural Steel

Properties of Structural Steel

Physical Properties (Cl. 2.2.4.1 of IS 800-2007, Page 12)

- Modulus of Elasticity E $= 2x10^5 N/mm^2$
- Modulus of Rigidity G $= 0.77x10^5 N/mm^2$
- Density $\rho = 7850 kg/m^3$
- Poisson's ratio $\upsilon = 0.30$ (elastic range)
  $= 0.50$ (plastic range)
- Coeffient of thermal expansion $\alpha = 12x10^{-6}/^oC$

Mechanical Properties

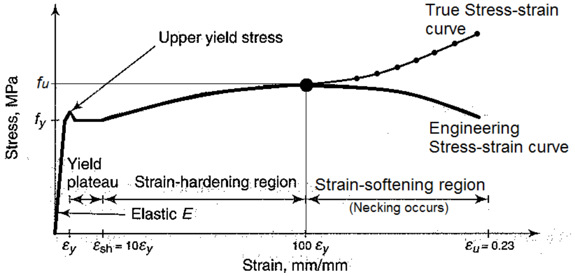
- Yield Strength & Ultimate Strength
- Ductility
- Hardness
- Toughness
- Weldability

Structural Steel

Mechanical Properties

1) **Ultimate Strength (f_u)**

- It is the minimum guaranteed ultimate tensile strength at which the steel fails.
- Obtained from Tension test on a standard specimen.
- Stress-strain diagram for a mild steel specimen subjected to gradually increasing tensile load is obtained as shown:



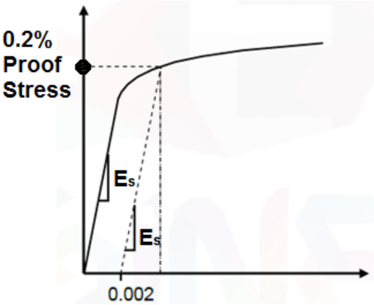
- Engineering Stress-strain curve uses Initial cross-sectional area of specimen; while True stress-strain curve uses actual cross-sectional area.

Structural Steel

Mechanical Properties

2) **Yield Stress (f_y)**

- It is the stress level at which the material undergoes large deformations.
- In *Mild steel*, there is a well-defined yield point (see previous slide).
- But in *High strength steel*, there may be no well-defined yield point. In such case, stress corresponding to 0.2% strain is adopted as Yield stress, which is known as "**Proof stress**".



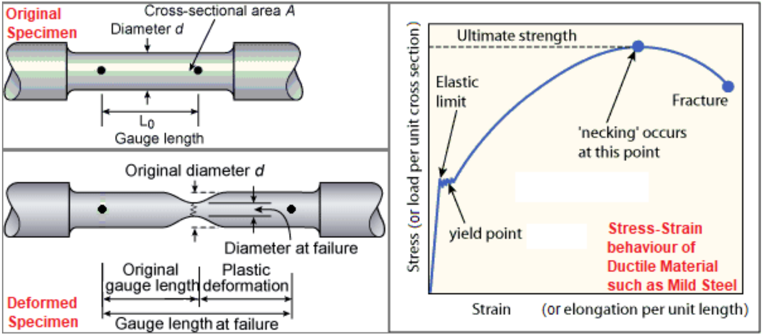
Structural Steel

Mechanical Properties

3) Ductility

- Ductility is the capacity to undergo large inelastic deformations without significant loss of stiffness.
- Ductility is measured by measuring the % elongation of the tension test specimen.

$$\% \text{ Elongation} = \frac{Gauge\ length\ at\ Failure\ -\ Original\ Gauge\ length}{Original\ Gauge\ length} \times 100$$

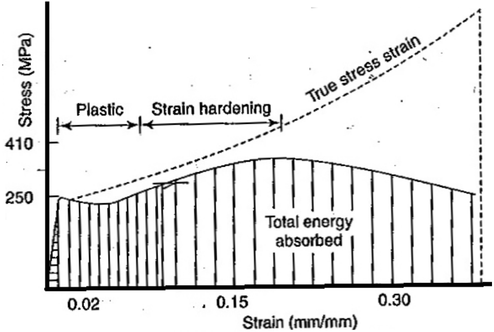


Structural Steel

Mechanical Properties

4) Toughness

- Toughness is the ability to resist fracture under impact loading.
- Area under stress strain curve is a measure of toughness.



- Important design parameter for structures subjected to impact loads (Eg: Bridges) and those subjected to seismic loads.

Structural Steel

Mechanical Properties

5) **Hardness**

- Hardness is the resistance to indentation & scratching.
- Tested by 3 methods -
  1. Brinell Hardness Test
  2. Rockwell Hardness Test
  3. Vicker Hardness Test .

6) **Weldability**

- Steel structural elements may be connected by weld. But the steel used must be weldable. Steel is weldable, if :
  1. Hardness is low.
  2. There is adequate elongation & notch toughness .

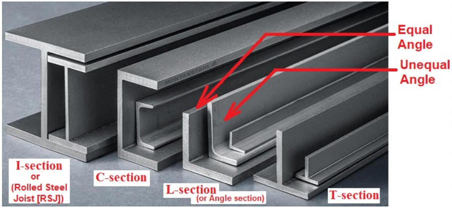
Structural Steel

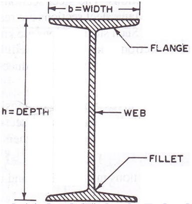
Types of sections

1) **I - sections** or **Rolled Steel Joists [RSJ]**

- Consists of a web and two sloping flanges.
- Different types of I-sections are:
  - Indian Standard Junior Beams (ISJB)
  - Indian Standard Light Beams (ISLB)
  - Indian Standard Medium Weight Beams (ISMB)
  - Indian Standard Wide Flange Beams (ISWB)
  - Indian Standard Heavy Weight Beams (ISHB)
- Designated in terms of depth (in mm) and unit weight (in kN/m),

  Eg: ISMB 225 @ 0.312 kN/m
- Generally, used as BEAMS; Flanges - resist Bending moment; Web - resist Shear force effectively.





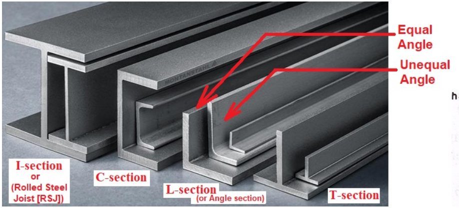
Structural Steel

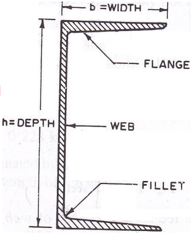
Types of sections

2) C - sections or Channel sections

- Consists of two sloping flanges standing out only to one side of web.
- Different types of Channels are:
    - Indian Standard Junior Channels (ISJC)
    - Indian Standard Light Channels (ISLC)
    - Indian Standard Medium Weight Channels (ISMC)
    - Indian Standard Medium Weight Parallel Flange Channels (ISMCP)
- Designated in terms of depth (in mm) and unit weight (in kN/m),

  Eg: ISMC 225 @ 0.261 kN/m
- Commonly used in columns, in trusses etc.





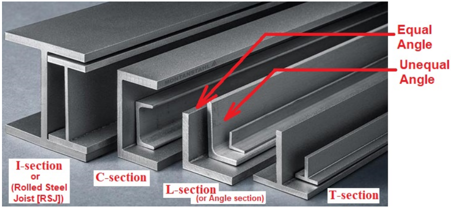
Structural Steel

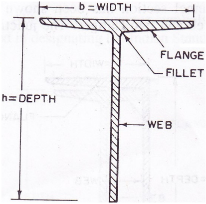
Types of sections

3) **T - sections**

- Consists of a web and a flange
- Different types of T-sections are:
  - Indian Standard Junior Tee (ISJT)
  - Indian Standard Light Tee (ISLT)
  - Indian Standard Normal Tee (ISNT)
  - Indian Standard Wide flange Tee (ISHT)
  - Indian Standard Long legged Tee (ISST)
- Designated in terms of depth (in mm) and unit weight (in kN/m),

  Eg: ISHT 125 @ 0.274 kN/m
- Used as brackets to columns, to connect plates in steel watertanks, etc.





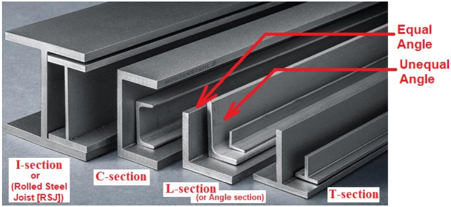
Structural Steel

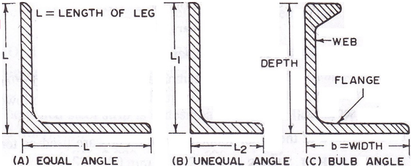
Types of sections

4) L - sections or Angle sections

- L-cross shaped section with two legs at 90_o.
- Different types of L-sections are:
  - Indian Standard Equal Angles (ISA)
  - Indian Standard Unequal Angles (ISA)
  - Indian Standard Bulb Angles (ISBA)
- Designated by length of legs and thickness (in mm),

  Eg: ISA 130 x 130 x 8; ISA 200 x 100 x 10
- Widely used in trusses.



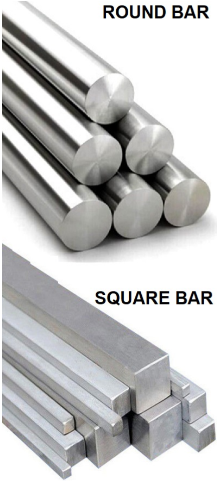


Structural Steel

Types of sections

5) **Bars**

- Different types of bars are:
  - Indian Standard Round bars (ISRO)
  - Indian Standard Square bars (ISSQ)
- Designated by diameter(in mm) for ISRO and side width(in mm) for ISSQ
- Widely used for fabrication, lateral bracing etc.



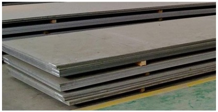
Structural Steel

Types of sections

6) **Flats**
   - Min. thickness =5mm
   - designated by the width (mm) followed by letters ISF and the thickness (mm).

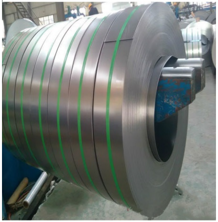
FLATS (t ≥ 5mm)

7) **Plates**
   - Min. thickness =5mm
   - designated as ISPL followed by figures denoting length (mm) X width (mm) x thickness (mm) of the plates.



PLATES (t ≥ 5mm)

8) **Strips**
   - Generally, of thickness <5mm
   - designated as ISST followed by figures denoting width (mm) X thickness (mm) of the strip.



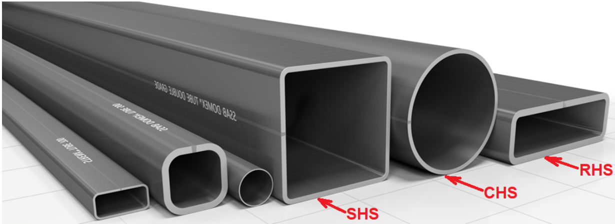
STRIPS (t < 5mm)

Structural Steel

Types of sections

9) **Tubes** or **Hollow sections**

- possess hollow crosssection.
- Thickness: 2 to 10mm
- Different types of Tubes are:
  - Circular Hollow Sections (CHS)
  - Square Hollow Sections (SHS)
  - Rectangular Hollow Sections (RHS)
- designated by its outside dimensions and thickness in millimetres
- Generally used in columns, trusses etc.



Advantages & Disadvantages of Steel structures over RCC structures

Advantages of Steel structures

- Strength-Weight ratio of structural steel is very high compared to RCC. Hence structural steel requires smaller cross sections to resist external loads.
- Precast structural steel sections are easily available and erection becomes faster.
- Since steel is a ductile material, failure of structures is neither abrupt nor catastrophic.
- It has 100% scrap value. It is recyclable; can be reused even after dismantling.
- It has longer life, if maintained properly.
- Since sections are all factory made, quality control is ensured.
- Strengthening of structures is relatively simpler. This can be performed by connecting additional sections to the existing sections.

Advantages & Disadvantages of Steel structures over RCC structures

Disadvantages of Steel structures

- Less fire resistance
- More susceptible to corrosion.
- High maintenance cost
- High initial cost of investment/installation
- Strength of steel sections reduce if subjected to large number of stress reversals (fatigue)

THANK YOU...